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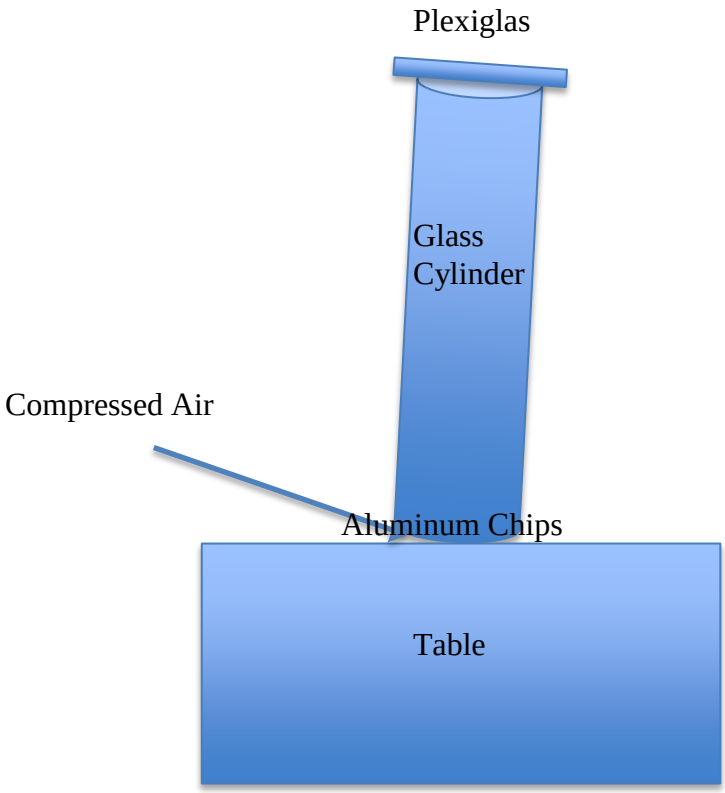
Flow Visualization

Spring 2014

This is the second flow visualization team project turned into the University of Colorado at Boulder. The inspiration and purpose behind this video was to create a vortex of some kind to demonstrate the beauty and science behind this phenomenon. Initially, the plan was to create the vortex using only compressed air however this proved very challenging and so several items were incorporated to control the flow of the air and material. The video demonstrates very fine aluminum chips being blown with compressed air inside a glass cylinder.

In order to create this video, a rather complex system was incorporated. A thin layer of very fine aluminum chips was placed on a table in a circular shape about an inch in diameter. Then, a hollow glass cylinder was placed over the chips and tilted ever so slightly to ensure air could pass over the aluminum. A piece of Plexiglas was placed over the top of the cylinder and video was taken by filming through this glass. Finally, compressed air was blown through the small slit at the bottom of the hollow cylinder in order to make the aluminum chips fly into the cylinder and create the desired vortex.



The glass cylinder was approximately a foot tall with a 1½-inch diameter. The compressed air speed was varied in order to create the best effect and it is impossible to deduce what the final speed was upon shooting the video. Also, the location of the compressed air with respect to the sidewalls of the glass cylinder was very important in

creating the desired results. It is important to note that varying the speed and angle of the air causes the height of the vortex to fluctuate rather dramatically, and it would be interesting to perform this test with a much longer glass cylinder to better determine the effect these variables have on height.

In fluid dynamics, a vortex is a spinning motion of fluid around an imaginary axis. Studies have shown that the flow of a vortex inside a cylinder can be defined by four variables: height of the cylinder, radius of the cylinder, constant angular speed of rotation, and the kinematic viscosity[1]. Unfortunately, the angular speed and kinematic viscosity were not measured in this experiment, which makes an analysis of the flow impossible. Vortices tend to form in stirred fluids, thus when the air is shot into the cylinder, it stirs up the metal chips and causes them to assume the same action as the air, which in this case will inevitably be a circular motion. According to Sir Isaac Newton's first law of motion, the air will move in a straight line unless something changes it's direction. In this case, the circular walls of the cylinder do just that and cause the airflow to constantly change direction[2]. The result of all this is that the air and aluminum flakes form this spinning circular motion inside the cylinder and create the beautiful flow phenomenon of a vortex.

This video was filmed using an Olympus Pen E-PL5. It was shot at a distance of approximately 6 inches and the focus changes throughout the video in an effort to illustrate what is happening. The camera shot 30 frames per second and the ISO was set at 200. With regards to final production value, no changes were made since I liked the background noise and the camera movements helped achieve different great views. It would not be incredibly difficult to replicate this setup although it might be challenging to get all the right equipment for the setup. Overall, the video demonstrates a very cool phenomenon that is rather appealing to the eye.

References:

1) "Axisymmetric Vortex Breakdown in an Enclosed Cylinder Flow" *Aeronautical Research Laboratory*. 6 April 2014 https://math.la.asu.edu/~lopez/pdf/LNP323_Lop89.pdf

2) "Exploring the Vortex" *Science Toy Maker*. 6 April 2014 http://www.sciencetoymaker.org/vortex/explore.htm